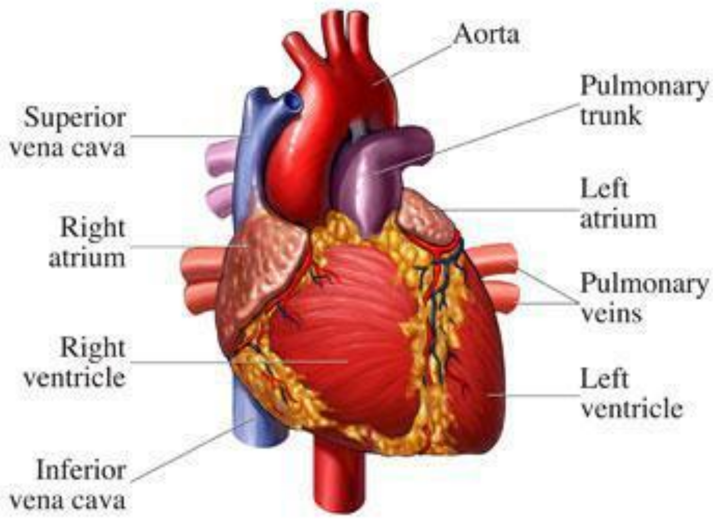
ELECTRONIC

STETHOSCOPE

(AS A TEACHING AID)

INDEX

Introduction to Human Heart:



The heart is essentially a muscle (a little larger than the fist). Like any other muscle in the human body, it contracts and expands. Unlike skeletal muscles, however, the heart works on the "All -or-Nothing Law". That is, each time the heart contracts it does so with all its force. In skeletal muscles, the principle of "gradation" is present. The pumping of the heart is called the Cardiac Cycle, which occurs about 72 times per minute. This means that each cycle lasts about eight-tenths of a second. During this cycle the entire heart actually rests for about four-tenths of a second.

The walls of the heart are made up of three layers, while the cavity is divided into four parts. There are two upper chambers, called the right and left atria, and two lower chambers, called the right and left ventricles. The Right Atrium, as it is called, receives blood from the upper and lower body through the superior vena cava and the inferior vena cava, respectively, and from the heart muscle itself through the coronary sinus. The right atrium is the larger of the two atria, having very thin walls. The right atrium opens into the right ventricle through the right atrioventicular valve (tricuspid), which only allows the blood to flow from the atria into the ventricle, but not in the reverse direction. The right ventricle pumps the blood to the lungs to be reoxygenated. The left atrium receives blood from the lungs via the four pulmonary veins. It is smaller than the right atrium, but has thicker walls. The valve between the left atrium and the left ventricle, the left atrioventicular valve (bicuspid), is smaller than the tricuspid. It opens into the left ventricle and again is a one way valve. The left ventricle pumps the blood throughout the body. It is the Aorta, the largest artery in the body, which originates from the left ventricle.

The Heart works as a pump moving blood around in our bodies to nourish every cell. Used blood, that is blood that has already been to the cells and has given up its nutrients to them, is drawn from the body by the right half of the heart, and then sent to the lungs to be reoxygenated. Blood that has been reoxygenated by the lungs is drawn into the left side of the heart and then pumped into the blood stream. It is the atria that draw the blood from the lungs and body, and the ventricles that pump it to the lungs and body. The output of each ventricle per beat is about 70 ml, or about 2 tablespoons. In a trained athlete this amount is about double. With the average heart rate of 72 beats per minute the heart will pump about 5 liters per ventricle, or about 10 liters total per minute. This is called the cardiac output. In a trained athlete the total cardiac output is about 20 liters. If we multiply the normal, non-athlete output by the average age of 70 years, we see that the cardiac output of the average human heart over a life time would be about 1 million liters, or about 250,000 gallons (US)!

36 Interesting Facts About . . .

The Human Heart

1. The average adult heart beats 72 times a minute; 100,000 times a day; 3,600,000 times a year; and 2.5 billion times during a lifetime.

2. Though weighing only 11 ounces on average, a healthy heart pumps 2,000 gallons of blood through 60,000 miles of blood vessels each day.

3. A kitchen faucet would need to be turned on all the way for at least 45 years to equal the amount of blood pumped by the heart in an average lifetime.

4. The volume of blood pumped by the heart can vary over a wide range, from five to 30 liters per minute.

5. Every day, the heart creates enough energy to drive a truck 20 miles. In a lifetime, that is equivalent to driving to the moon and back.
6. Because the heart has its own electrical impulse, it can continue to beat even when separated from the body, as long as it has an adequate supply of oxygen.

7. The fetal heart rate is approximately twice as fast as an adult's, at about 150 beats per minute. By the time a fetus is 12 weeks old, its heart pumps an amazing 60 pints of blood a day.

8. The heart pumps blood to almost all of the body's 75 trillion cells. Only the corneas receive no blood supply.

9. During an average lifetime, the heart will pump nearly 1.5 million gallons of blood—enough to fill 200 train tank cars.


Ahealthy heart pumps approximately 2,000 gallons of blood a day

10. Five percent of blood supplies the heart, 15-20% goes to the brain and central nervous system, and 22% goes to the kidneys.

11. The ―thump-thump‖ of a heartbeat is the sound made by the four valves of the heart closing.

12. The heart does the most physical work of any muscle during a lifetime. The power output of the heart ranges from 1-5 watts. While the quadriceps can produce 100 watts for a few minutes, an output of one watt for 80 years is equal to 2.5 gigajoules.

13. The heart begins beating at four weeks after conception and does not stop until death.

14. A newborn baby has about one cup of blood in circulation. An adult human has about four to five quarts which the heart pumps to all the tissues and to and from the lungs in about one minute while beating 75 times.

15. The heart pumps oxygenated blood through the aorta (the largest artery) at about 1 mile (1.6 km) per hour. By the time blood reaches the capillaries, it is moving at around 43 inches (109 cm) per hour.

16. Early Egyptians believed that the heart and other major organs had wills of their own and would move around inside the body.

17. An anonymous contributor to the Hippocratic Collection (or Canon) believed vessel valves kept impurities out of the heart, since the intelligence of man was believed to lie in the left cavity.

18. Plato theorized that reasoning originated with the brain, but that passions originated in the ―fiery‖ heart.

19. The term ―heartfelt‖ originated from Aristotle's philosophy that the heart collected sensory input from the peripheral organs through the blood vessels. It was from those perceptions that thought and emotions arose.

20. Prolonged lack of sleep can cause irregular jumping heartbeats called premature ventricular contractions (PVCs).

21. Some heavy snorers may have a condition called obtrusive sleep apnea (OSA), which can negatively affect the heart.

22. Cocaine affects the heart's electrical activity and causes spasm of the arteries, which can lead to a heart attack or stroke, even in healthy people.

23. Galen of Pergamum, a prominent surgeon to Roman gladiators, demonstrated that blood, not air, filled arteries, as Hippocrates had concluded. However, he also believed that the heart acted as a low-temperature oven to keep the blood warm and that blood trickled from one side of the heart to other through tiny holes in the heart.

24. Galen agreed with Aristotle that the heart was the body's source of heat, a type of ―lamp‖ fueled by blood from the liver and fanned into spirituous flame by air from the lungs. The brain merely served to cool the blood.

25. In 1929, German surgeon Werner Forssmann (1904-1979) examined the inside of his own heart by threading a catheter into his arm vein and pushed it 20 inches and into his heart, inventing cardiac catheterization, a now common procedure.

26. On December 3, 1967, Dr. Christian Barnard (1922-2001) of South Africa transplanted a human heart into the body of Louis Washansky. Although the recipient lived only 18 days, it is considered the first successful heart transplant.

27. ―Atrium‖ is Latin for ―entrance hall,‖ and ―ventricle‖ is Latin for ―little belly.

28. A woman's heart typically beats faster than a man's. The heart of an average man beats approximately 70 times a minute, whereas the average woman has a heart rate of 78 per minute.

29. Blood is actually a tissue. When the body is at rest, it takes only six seconds for the blood to go from the heart to the lungs and back, only eight seconds for it to go the brain and back, and only 16 seconds for it to reach the toes and travel all the way back to the heart.

30. French physician Rene Laennec (1781-1826) invented the stethoscope when he felt it was inappropriate to place his ear on his large-buxomed female patients' chests.

31. Physician Erasistratus of Chios (304-250 B.C.) was the first to discover that the heart functioned as a natural pump.

32. In his text *De Humani Corporis Fabrica Libri Septem*, the father of modern anatomy, Andreas Vesalius (1514-1564), argued that the blood seeped from one ventricle to another through mysterious pores.

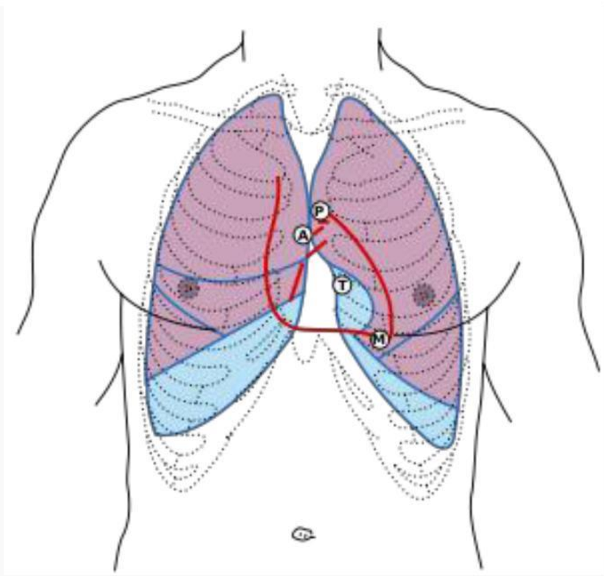
33. Galen argued that the heart constantly produced blood. However, William Harvey's (1578-1657) discovery of the circulation system in 1616 revealed that there was a finite amount of blood in the body and that it circulated in one direction.

34. The right atrium holds about 3.5 tablespoons of blood. The right ventricle holds slightly more than a quarter cup of blood. The left atrium holds the same amount of blood as the right, but its walls are three times thicker.

35. Grab a tennis ball and squeeze it tightly: that's how hard the beating heart works to pump blood.

36. In 1903, physiologist Willem Einthoven (1860-1927) invented the electrocardiograph, which measures electric current in the heart.

HEART SOUNDS:



Front of thorax, showing surface relations of bones, lungs (purple), pleura (blue), and heart (red outline). The location of best auscultation for each heart valve are labeled with "M", "T", "A", and "P".

First heart sound: caused by atrioventricular valves - Mitral(M) and Tricuspid (T).

Second heart sound caused by semilunar valves -- Aortic(A) and Pulmonary/ Pulmonic(P).

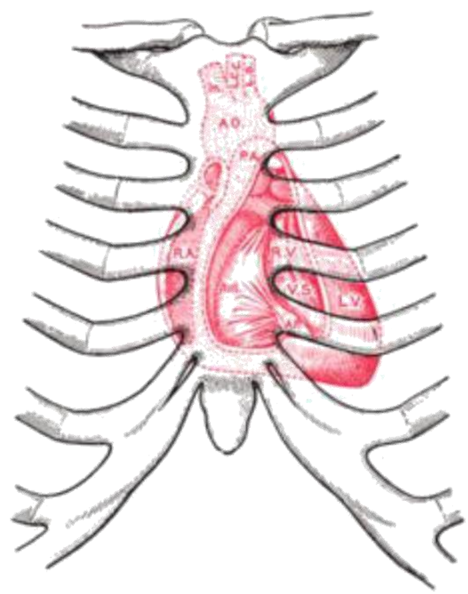


Diagram showing relations of opened heart to front of thoracic wall.

Ant. : Anterior segment of tricuspid valve.

A O. : Aorta.

A.P. : Anterior papillary muscle.

In. : Innominate artery.

L.C.C. : Left common carotid artery.

L.S. : Left subclavian artery.

L.V. : Left ventricle.

P.A. : Pulmonary artery.

R.A. : Right atrium.

R.V. : Right ventricle.

V.S. : Ventricular septum.

Heart sounds, or **heartbeats**, are the noises generated by the beating heart and the resultant flow of blood through it (specifically, the turbulence created when the heart valves snap shut). In cardiac auscultation, an examiner may use a stethoscope to listen for these unique and distinct sounds that provide important auditory data regarding the condition of the heart to a trained observer.

In healthy adults, there are two normal heart sounds often described as a *lub* and a *dub* (or *dup*), that occur in sequence with each heartbeat. These are the **first heart sound** (S_1) and **second heart sound** (S_2), produced by the closing of the AV valves and semilunar valves respectively. In addition to these normal sounds, a variety of other sounds may be present including *heart murmurs*, *adventitious sounds*, and gallop rhythmsS_3 and S_4.

Heart murmurs are generated by turbulent flow of blood, which may occur inside or outside the heart. Murmurs may be *physiological* (benign) or*pathological* (abnormal). Abnormal murmurs can be caused by stenosis restricting the opening of a heart valve, resulting in turbulence as blood flows through it. Abnormal murmurs may also occur with valvular *insufficiency* (or *regurgitation*), which allows backflow of blood when the incompetent valve closes with only partial effectiveness. Different murmurs are audible in different parts of the cardiac cycle, depending on the cause of the murmur.

PRIMARY HEART SOUNDS

Normal heart sounds are associated with heart valves closing, causing changes in blood flow.

First heart sound (S_1):

The first heart tone, or $\mathbf{S_1}$, forms the "lub" of "lub-dub" and is composed of components M_1 and T_1. Normally M_1 precedes T_1 slightly. It is caused by the sudden block of reverse blood flow due to closure of the atrioventricular valves, i.e. tricuspid and mitral (bicuspid), at the beginning of ventricular contraction, or systole. When the ventricles begin to contract, so do the papillary muscles in each ventricle. The papillary muscles are attached to the tricuspid and mitral valves via chordae tendineae, which bring the cusps or leaflets of the valve closed (chordae tendineae also prevent the valves from blowing into the atria as ventricular pressure rises due to contraction). The closing of the inlet valves prevents regurgitation of blood from the ventricles back into the atria. The $\mathbf{S_1}$ sound results from reverberation within the blood associated with the sudden block of flow reversal by the valves.[1] If T_1occurs more than slightly after M_1, then the patient likely has a dysfunction of conduction of the right side of the heart such as a right bundle branch block.

Second heart sound (S2):

The second heart tone, or **S_2**, forms the "dub" of "lub-dub" and is composed of components A_2 and P_2. Normally A_2 precedes P_2 especially during inspiration when a split of S_2 can be heard. It is caused by the sudden block of reversing blood flow due to closure of the semilunar valves (the aortic valve and pulmonary valve) at the end of ventricular systole, i.e. beginning of ventricular diastole. As the left ventricle empties, its pressure falls below the pressure in the aorta. Aortic blood flow quickly reverses back toward the left ventricle, catching the pocket like cusps of the aortic valve, and is stopped by aortic (outlet) valve closure. Similarly, as the pressure in the right ventricle falls below the pressure in the pulmonary artery, the pulmonary (outlet) valve closes. The **S_2** sound results from reverberation within the blood associated with the sudden block of flow reversal.

Splitting of S2, also known as physiological split, normally occurs during inspiration because the decrease in intrathoracic pressure increases the time needed for pulmonary pressure to exceed that of the right ventricular pressure. A widely split S2 can be associated with several different cardiovascular conditions, including right bundle branch block and pulmonary stenosis.

EXTRA HEART SOUNDS

The rarer extra heart sounds form gallop rhythms and are heard in both normal and abnormal situations.

Third heart sound (S3):

Rarely, there may be a third heart sound also called a **protodiastolic gallop**, **ventricular gallop**, or informally the "Kentucky" gallop as an onomatopoeic reference to the rhythm and stress of S1 followed by S2 and S3 together (S1=Ken; S2=tuck; S3=y).

"lub-dub-ta" or "slosh-ing-in" If new indicates heart failure or volume overload.

It occurs at the beginning of diastole after S2 and is lower in pitch than S1 or S2 as it is not of valvular origin. The third heart sound is benign in youth, some trained athletes, and sometimes in pregnancy but if it re-emerges later in life it may signal cardiac problems like a failing left ventricle as in dilated congestive heart failure (CHF). S3 is thought to be caused by the oscillation of blood back and forth between the walls of the ventricles initiated by inrushing blood from the atria. The reason the third heart sound does not occur until the middle third of diastole is probably because during the early part of diastole, the ventricles are not filled sufficiently to create enough tension for reverberation.

It may also be a result of tensing of the chordae tendineae during rapid filling and expansion of the ventricle. In other words, an S3 heart sound indicates increased volume of blood within the ventricle. An S3 heart sound is best heard with the bell-side of the stethoscope (used for lower frequency sounds). A left-sided S3 is best heard in the left lateral decubitus position and at the apex of the heart, which is normally located in the 5th left intercostal space at the midclavicular line.[2] A right-sided S3 is best heard at the lower-left sternal border. The way to distinguish between a left and right-sided S3 is to observe whether it increases in intensity with inspiration or expiration. A right-sided S3 will increase on inspiration whereas a left-sided S3 will increase on expiration.

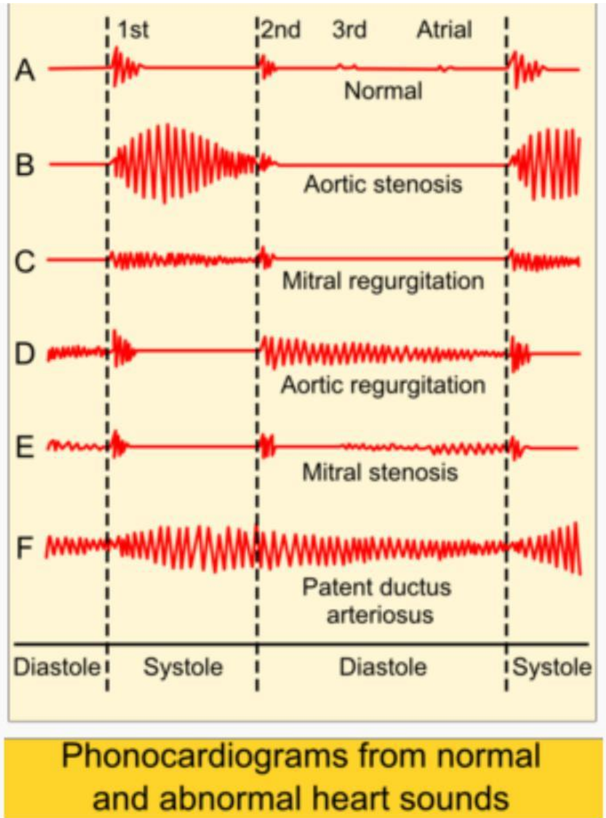
Fourth heart sound (S4):

The rare fourth heart sound when audible in an adult is called a **presystolic gallop** or **atrial gallop**. This gallop is produced by the sound of blood being forced into a stiff/hypertrophic ventricle.

"ta-lub-dub" or "a-stiff-wall"

It is a sign of a pathologic state, usually a failing left ventricle, but can also be heard in other conditions such as restrictive cardiomyopathy. The sound occurs just after atrial contraction ("atrial kick") at the end of diastole and immediately before S1, producing a rhythm sometimes referred to as the "Tennessee" gallop where S4 represents the "Ten-" syllable. It is best heard at the cardiac apex with the patient in the left lateral decubitus position and holding his breath. The combined presence of S3 and S4 is a **quadruple gallop**, also known as the "Hello-Goodbye" gallop. At rapid heart rates, S3 and S4 may merge to produce a **summation gallop** (sometimes referred to as S7).

Murmurs:



Auscultogram from normal and abnormal heart sounds

Heart murmurs are produced as a result of turbulent flow of blood, turbulence sufficient to produce audible noise. They are usually heard as a whooshing sound. The term murmur only refers to a sound believed to originate within blood flow through or near the heart; rapid blood velocity is necessary to produce a murmur. Yet most heart problems do not produce any murmur and most valve problems also do not produce an audible murmur.

The following paragraphs overview the murmurs most commonly heard in adults who do not have major congenital heart abnormalities.

- Regurgitation through the mitral valve is by far the most commonly heard murmur, producing a pansystolic murmur which is sometimes fairly loud to a practiced ear, even though the volume of regurgitant blood flow may be quite small. Yet, though obvious using echocardiography visualization, probably about 20% of cases of mitral regurgitation does not produce an audible murmur.

- Stenosis of the aortic valve is typically the next most common heart murmur, a systolic ejection murmur. This is more common in older adults or in those individuals having a two, not a three leaflet aortic valve.
- Regurgitation through the aortic valve, if marked, is sometimes audible to a practiced ear with a high quality, especially electronically amplified, stethoscope. Generally, this is a very rarely heard murmur, even though aortic valve regurgitation is not so rare. Aortic regurgitation, though obvious using echocardiography visualization, usually does not produce an audible murmur.
- Stenosis of the mitral valve, if severe, also rarely produces an audible, low frequency soft rumbling murmur, best recognized by a practiced ear using a high quality, especially electronically amplified, stethoscope.
- Either regurgitation through, or stenosis of, the tricuspid or pulmonary valves essentially never produces audible murmurs.
- Other audible murmurs are associated with abnormal openings between the left ventricle and right heart or from the aortic or pulmonary arteries back into a lower pressure heart chamber.

Gradations of Murmurs[1]	(Defined based on use of an acoustic, not a high-fidelity amplified electronic stethoscope)
Grade	**Description**
Grade 1	Very faint, heard only after listener has "tuned in"; may not be heard in all positions. Only heard if the patient "bears down" or performs the Valsalva maneuver.
Grade 2	Quiet, but heard immediately after placing the stethoscope on the chest.
Grade 3	Moderately loud.
Grade 4	Loud, with palpable thrill (i.e., a tremor or vibration felt on palpation)[3]
Grade 5	Very loud, with thrill. May be heard when stethoscope is partly off the chest.
Grade 6	Very loud, with thrill. May be heard with stethoscope entirely off the chest.

As noted, several different cardiac conditions can cause heart murmurs. However, the murmurs produced often change in complex ways with the severity of the cardiac disease. An astute physician can sometimes diagnose cardiac conditions with some accuracy based largely on the murmur, related physical examination and experience with the relative frequency of different heart conditions. However, with the advent of better quality and wider availability of echocardiography and other techniques, heart status can be recognized and quantified much more accurately than formerly possible with only a stethoscope, examination and experience.

Effects of inhalation/expiration:

Inhalation pressure causes an increase in the venous blood return to the right side of the heart. Therefore, *right-sided murmurs generally increase in intensity with inspiration*. The increased volume of blood entering the right sided chambers of the heart restricts the amount of blood entering the left sided chambers of the heart. This causes left-sided murmurs to generally decrease in intensity during inspiration.

With expiration, the opposite hemodynamic changes occur. This means that left-sided murmurs generally increase in intensity with expiration. Having the patient lie supine and raising their legs up to a 45 degree angle facilitates an increase in venous return to the right side of the heart producing effects similar to inhalation-increased blood flow.

Interventions that change murmurs:

There are a number of interventions that can be performed that alter the intensity and characteristics of abnormal heart sounds. These interventions can differentiate the different heart sounds to more effectively obtain a diagnosis of the cardiac anomaly that causes the heart sound.

OTHER ABNORMAL SOUNDS

Clicks: With the advent of newer, non-invasive imaging techniques, the origin of other, so-called *adventitial* sounds or "clicks" has been appreciated. These are short, high-pitched sounds.

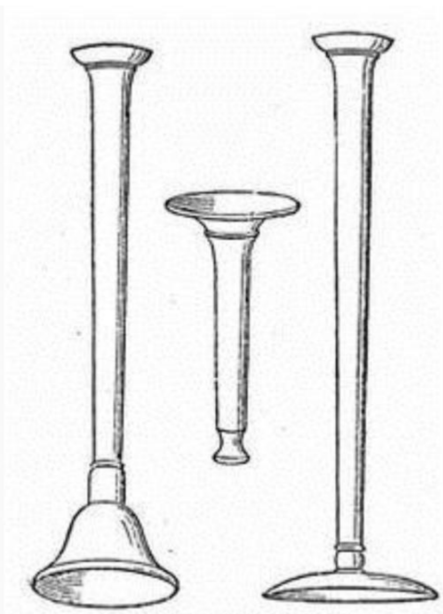
Rubs: Patients with pericarditis, an inflammation of the sac surrounding the heart (pericardium), may have an audible pericardial friction rub. This is a characteristic scratching, creaking, high-pitched sound emanating from the rubbing of both layers of inflamed pericardium. It is the loudest in systole, but can often be heard at the beginning and at the end of diastole. It is very dependent on body position and breathing, and changes from hour to hour.

Recording Heart Sounds

Using electronic stethoscopes, it is possible to record heart sounds via direct output to an external recording device, such as a laptop or MP3 recorder. The same connection can be used to listen to the previously-recorded auscultation through the stethoscope headphones, allowing for more detailed study of murmurs and other heart sounds, for general research as well as evaluation of a particular patient's condition.

Stethoscope

History

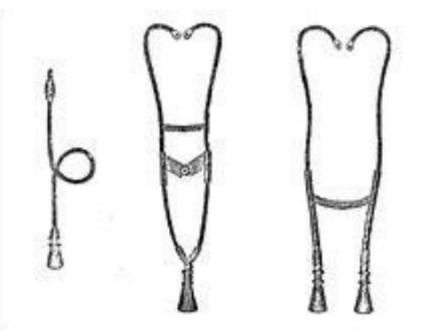


Hörrohr (Stethoskop).

Early stethoscopes:

The stethoscope was invented in France in 1816 by René Laennec at the Necker-Enfants Malades Hospital in Paris. It consisted of a wooden tube and was monaural. His device was similar to the common ear trumpet, a historical form of hearing aid; indeed, his invention was almost indistinguishable in structure and function from the trumpet, which was commonly called a "microphone". The first flexible stethoscope of any sort may have been a binaural instrument with articulated joints not very clearly described in 1829. In 1840, Golding Bird described a stethoscope he had been using with a flexible tube. Bird was the first to publish a description of such a stethoscope but he noted in his paper the prior existence of an earlier design (which he thought was of little utility) which he described as the snake ear trumpet. Bird's stethoscope had a single earpiece. In 1851, Irish physician Arthur Leared invented a binaural stethoscope, and in 1852 George Cammann perfected the design of the instrument for commercial production, which has become the standard ever since. Cammann also wrote a major treatise on diagnosis by auscultation, which the refined binaural stethoscope made possible. By 1873, there were descriptions of a differential stethoscope that could connect to slightly different locations to create a slight stereo effect, though this did not become a standard tool in clinical practice.

Rappaport and Sprague designed a new stethoscope in the 1940s, which became the standard by which other stethoscopes are measured, consisting of two sides, one of which is used for the respiratory system, the other for the cardiovascular system. The Rappaport-Sprague was later made by Hewlett-Packard. HP's medical products division was spun off as part of Agilent Technologies, Inc., where it became Agilent Healthcare. Agilent Healthcare was purchased by Philips which became Philips Medical Systems, before the walnut-boxed, $300, original Rappaport-Sprague stethoscope was finally abandoned ca. 2004, along with Philips' brand (manufactured by Andromed, of Montreal, Canada) electronic stethoscope model. The Rappaport-Sprague model stethoscope was heavy and short (18–24 in (46–61 cm)) with an antiquated appearance recognizable by their two large independent latex rubber tubes connecting an exposed-leaf-spring-joined-pair of opposing "f"-shaped chrome-plated brass binaural ear tubes with a dual-head chest piece.



Early flexible tube stethoscopes. Golding Bird's instrument is on the left. The instrument on the right was current around 1855 when this image was first published.

Several other minor refinements were made to stethoscopes, until in the early 1960s Dr. David Littmann, a Harvard Medical School professor, created a new stethoscope that was lighter than previous models and had improved acoustics. In the late 1970s, 3M-Littmann introduced the tunable diaphragm: a very hard (G-10) glass-epoxy resin diaphragm member with an overmolded silicone flexible acoustic surround which permitted increased excursion of the diaphragm member in a "z"-axis with respect to the plane of the sound collecting area. The left shift to a lower resonant frequency increases the volume of some low frequency sounds due to the longer waves propagated by the increased excursion of the hard diaphragm member suspended in the concentric accountic surround. Conversely, restricting excursion of the diaphragm by pressing the stethoscope diaphragm surface firmly against the anatomical area overlying the physiological sounds of interest, the acoustic surround could also be used to dampen excursion of the diaphragm in response to "z"-axis pressure against a concentric fret. This raises the frequency bias by shortening the wavelength to auscultate a higher range of physiological sounds. 3-M Littmann is also credited with a collapsible mold frame for sludge molding a single column bifurcating stethoscope tube with an internal septum dividing the single column stethoscope tube into discrete left and right binaural channels (AKA "cardiology tubing"; including a covered, or internal leaf spring-binaural ear tube connector).

In 1999, Richard Deslauriers patented the first external noise reducing stethoscope, the DRG Puretone. It featured two parallel lumens containing two steel coils which dissipated infiltrating noise as inaudible heat energy. The steel coil "insulation" added .30 lb to each stethoscope. In 2005, DRG's diagnostics division was acquired by TRIMLINE Medical Products.

CURRENT PRACTICE:

A German physician listens to a patient's lower lung regions with a stethoscope applied to his back.

Stethoscopes are often considered as a symbol of the doctor's profession, as doctors are often seen or depicted with a stethoscope hanging around their neck.

TYPES OF STETHOSCOPES:

Acoustic:

Acoustic stethoscopes are familiar to most people, and operate on the transmission of sound from the chest piece, via air-filled hollow tubes, to the listener's ears. The chest piece usually consists of two sides that can be placed against the patient for sensing sound; a diaphragm (plastic disc) or bell (hollow cup). If the diaphragm is placed on the patient, body sounds vibrate the diaphragm, creating acoustic pressure waves which travel up the tubing to the listener's ears. If the bell is placed on the patient, the vibrations of the skin directly produce acoustic pressure waves traveling up to the listener's ears. The bell transmits low frequency sounds, while the diaphragm transmits higher frequency sounds. This two-sided stethoscope was invented by Rappaport and Sprague in the early part of the 20th century. One problem with acoustic stethoscopes was that the sound level is extremely low. This problem was surmounted in 1999 with the invention of the stratified continuous (inner) lumen, and the kinetic acoustic mechanism in 2002. Acoustic stethoscopes are the most commonly used. A recent independent review evaluated twelve common acoustic stethoscopes on the basis of loudness, clarity, and ergonomics. They did acoustic laboratory testing and recorded heart sounds on volunteers. The results are listed by brand and model.

Electronic:

An electronic stethoscope (or stethophone) overcomes the low sound levels by electronically amplifying body sounds. However, amplification of stethoscope contact artifacts, and component cutoffs (frequency response thresholds of electronic stethoscope microphones, pre-amps, amps, and speakers) limit electronically amplified stethoscopes' overall utility by amplifying mid-range sounds, while simultaneously attenuating high- and low- frequency range sounds. Currently, a number of companies offer electronic stethoscopes. Electronic stethoscopes require conversion of acoustic sound waves to electrical signals which can then be amplified and processed for optimal listening. Unlike acoustic stethoscopes, which are all based on the same physics, transducers in electronic stethoscopes vary widely. The simplest and least effective method of sound detection is achieved by placing a microphone in the chest piece. This method suffers from ambient noise interference and has fallen out of favor. Another method, used in Welch-Allyn's Meditron stethoscope, comprises placement of a piezoelectric crystal at the head of a metal shaft, the bottom of the shaft making contact with a diaphragm. 3M also uses a piezo-electric crystal placed within foam behind a thick rubber-like diaphragm. Thinklabs' Rhythm 32 inventor, Clive Smith uses an Electromagnetic Diaphragm with a conductive inner surface to form a capacitive sensor. This diaphragm responds to sound waves identically to a conventional acoustic stethoscope, with changes in an electric field replacing changes in air pressure. This preserves the sound of an acoustic stethoscope with the benefits of amplification.

Because the sounds are transmitted electronically, an electronic stethoscope can be a wireless device, can be a recording device, and can provide noise reduction, signal enhancement, and both visual and audio output. Around 2001, Stethographics introduced PC-based software which enabled a phonocardiograph, graphic representation of cardiologic and pulmonologic sounds to be generated, and interpreted according to related algorithms. All of these features are helpful for purposes of telemedicine (remote diagnosis) and teaching.

Electronic stethoscopes are also used with Computer-aided Auscultation programs to analyze the recorded heart sounds pathological or innocent heart murmurs.

Recording stethoscopes:

Some electronic stethoscopes feature direct audio output that can be used with an external recording device, such as a laptop or MP3 recorder. The same connection can be used to listen to the previously-recorded auscultation through the stethoscope headphones, allowing for more detailed study for general research as well as evaluation and consultation regarding a particular patient's condition and telemedicine, or remote diagnosis.

Fetal stethoscope:

A fetal stethoscope or fetoscope is an acoustic stethoscope shaped like a listening trumpet. It is placed against the abdomen of a pregnant woman to listen to the heart sounds of the fetus. The fetal stethoscope is also known as a Pinard's stethoscope or a pinard, after French obstetrician Adolphe Pinard (1844–1934).

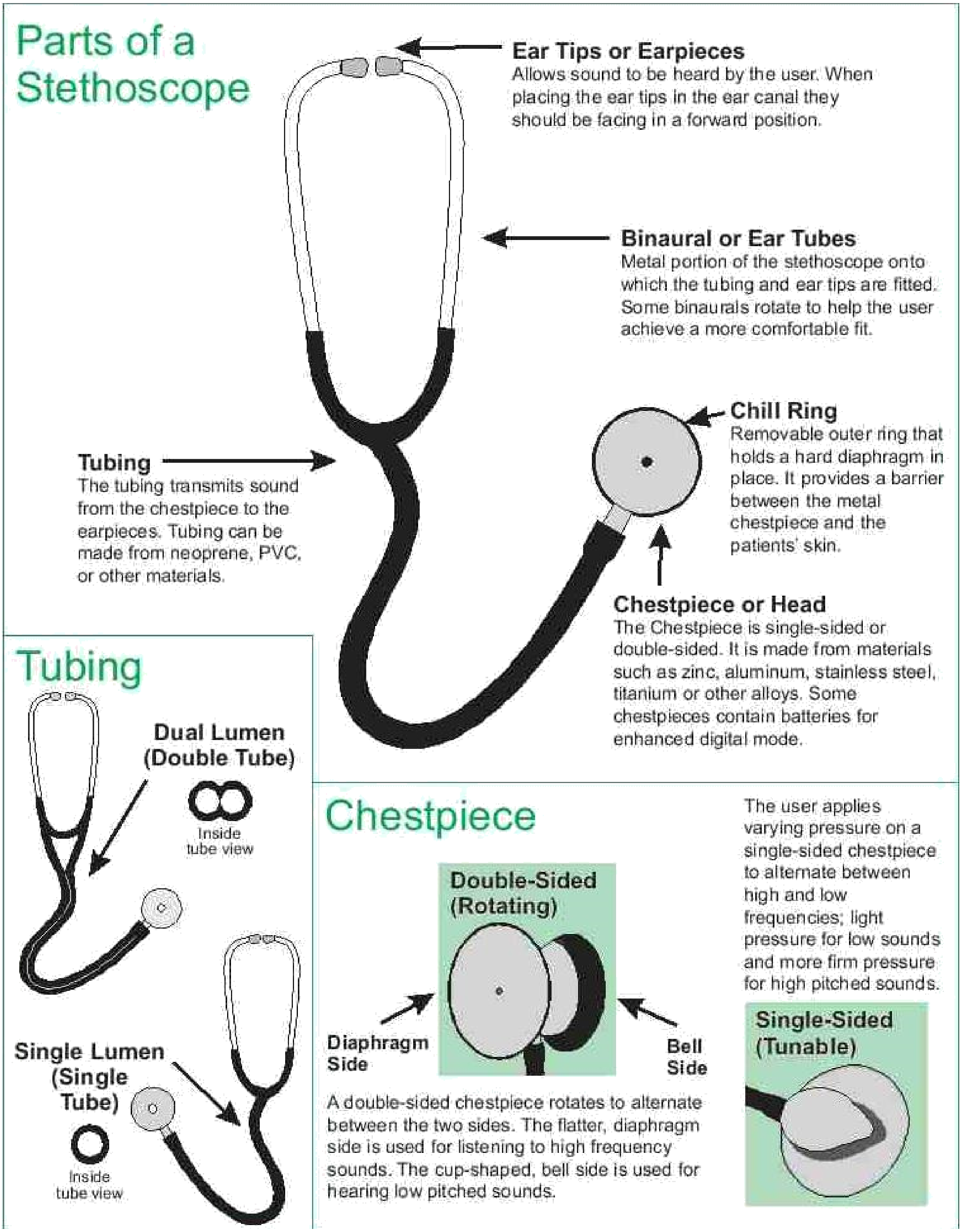
STETHOSCOPE EARPIECES

Stethoscopes usually have rubber earpieces which aid comfort and create a seal with the ear improving the acoustic function of the device. Stethoscopes can be modified by replacing the standard earpieces with moulded versions which improve comfort and transmission of sound. Moulded earpieces can be cast by an audiologist or made by the stethoscope user from a kit.

MAINTENANCE

The flexible vinyl, rubber, and plastic parts of stethoscopes should be kept away from solvents, including alcohol and soap. Solvents can have detrimental effects, including accelerating the natural aging process by dissolving the plasticizers that keep these parts flexible and looking new. In addition, when they are manufactured stethoscopes with two-sided chest pieces are lubricated where the chest piece rotates around the stem and need to be re-lubricated periodically, just like any other machine. If these moving parts are not lubricated, they grind together and ruin the fine tolerances required for the proper acoustic performance of the stethoscope. Cleaning the stethoscope will also remove lubricants, making periodic lubrication essential. Most lubricants must be kept away from rubber, vinyl, and plastic parts.

Only products that have been tested to be safe and effective for cleaning stethoscopes and similar medical instruments should be used.


Parts of a Stethoscope
Ear Tips or Earpieces
Allows sound to be heard by the user. When placing the ear tips in the ear canal they should be facing in a forward position.
Binaural or Ear Tubes
Metal portion of the stethoscope onto which the tubing and ear tips are fitted. Some binaurals rotate to help the user achieve a more comfortable fit.
Chill Ring
Removable outer ring that holds a hard diaphragm in place. It provides a barrier between the metal chestpiece and the patients' skin.
Tubing
The tubing transmits sound from the chestpiece to the earpieces. Tubing can be made from neoprene, PVC, or other materials.
Chestpiece or Head
The Chestpiece is single-sided or double-sided. It is made from materials such as zinc, aluminum, stainless steel, titanium or other alloys. Some chestpieces contain batteries for enhanced digital mode.
Tubing
Dual Lumen (Double Tube)
Inside tube view
Single Lumen (Single Tube)
Inside tube view
Chestpiece
Double-Sided (Rotating)
Diaphragm Side
Bell Side
A double-sided chestpiece rotates to alternate between the two sides. The flatter, diaphragm side is used for listening to high frequency sounds. The cup-shaped, bell side is used for hearing low pitched sounds.
The user applies varying pressure on a single-sided chestpiece to alternate between high and low frequencies; light pressure for low sounds and more firm pressure for high pitched sounds.
Single-Sided (Tunable)

ELECTRONIC STETHOSCOPE

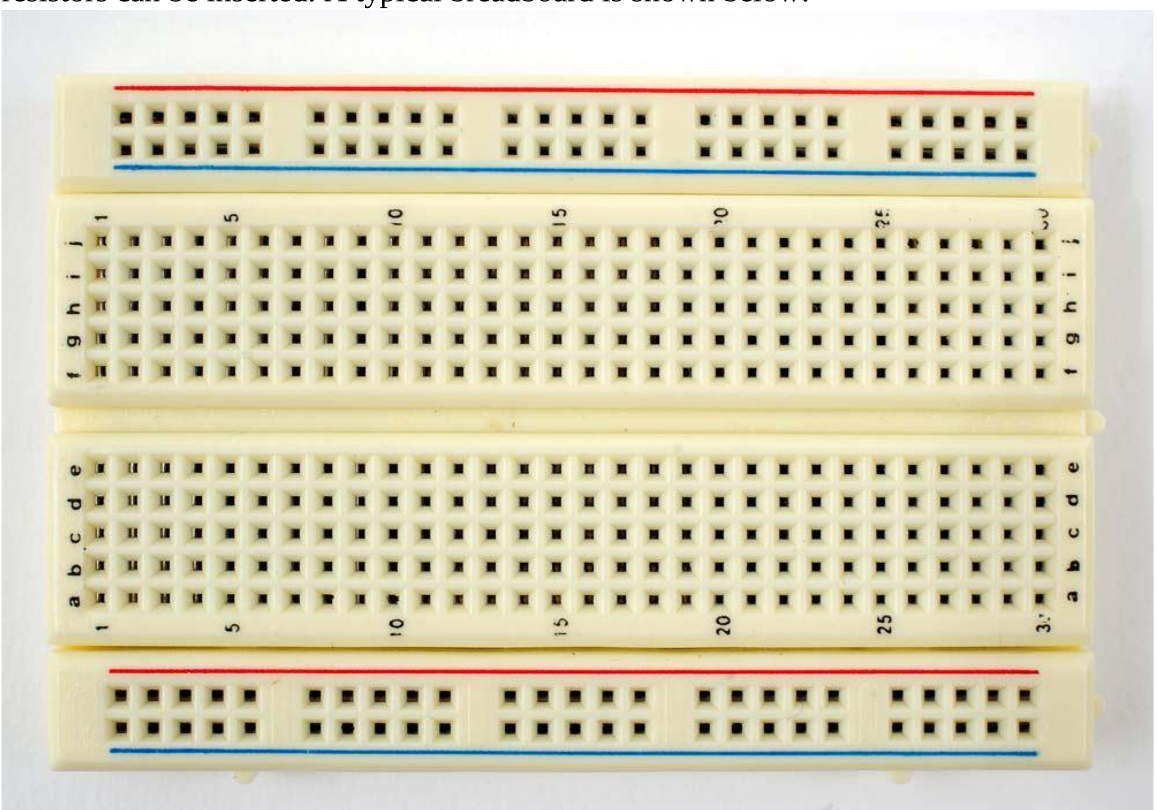
Stethoscopes are not only useful for doctors, but home mechanics, exterminators, spying and any number of other uses. Standard stethoscopes provide no amplification which limits their use. This circuit uses op-amps to greatly amplify a standard stethoscope, and includes a low pass filter to remove background noise.

HARDWARE IMPLEMENTATION:

Hardware implementation has been done on a solder less breadboard utilizing the following components which are described as follows.

Breadboard:

A breadboard is used to build and test circuits quickly before finalizing any circuit design. The breadboard has many holes into which circuit components like ICs and resistors can be inserted. A typical breadboard is shown below:



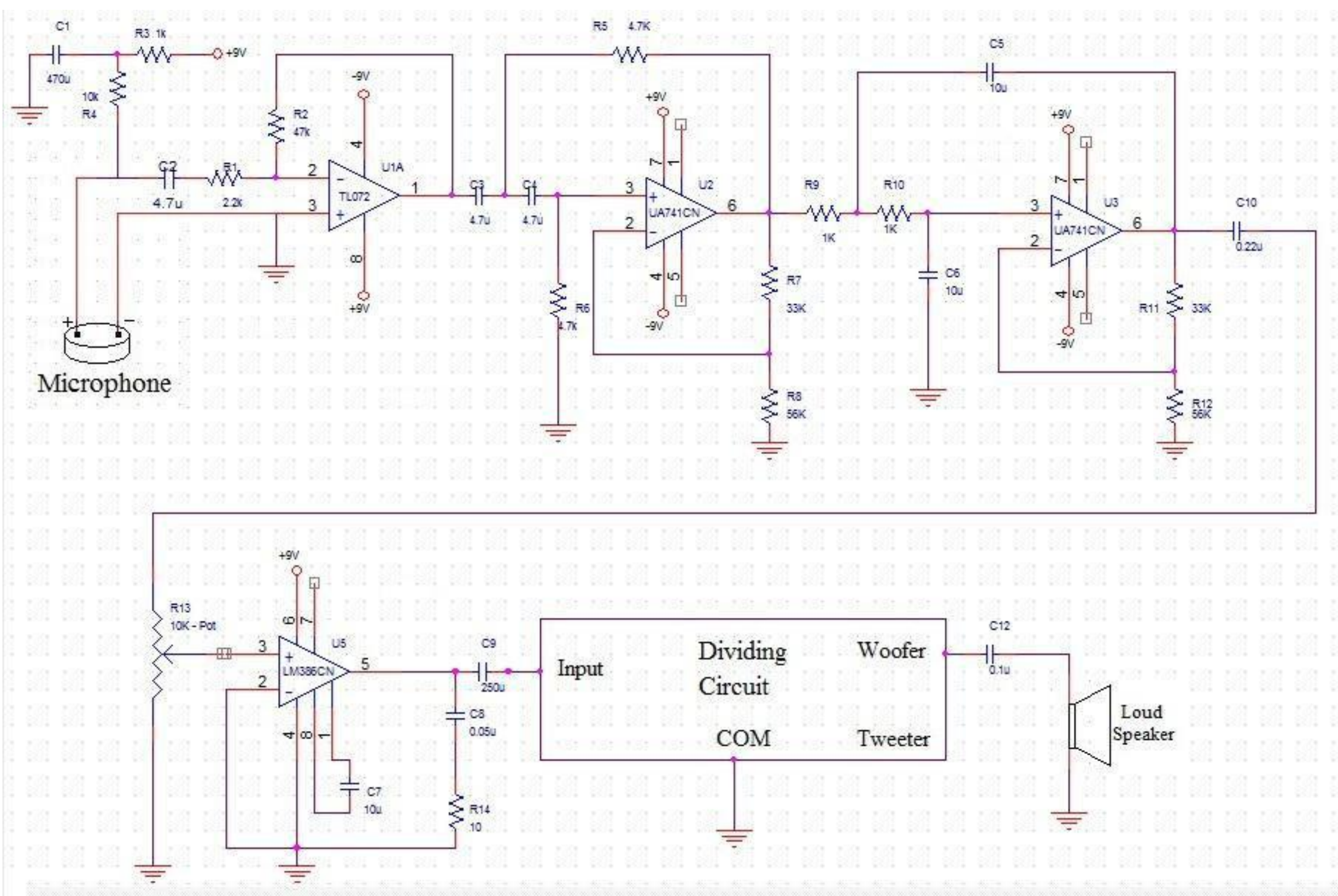
The bread board has strips of metal which run underneath the board and connect the holes on the top of the board. The metal strips are laid out as shown below. Note that the top and bottom rows of holes are connected horizontally while the remaining holes are connected vertically.

To use the bread board, the legs of components are placed in the holes. Each set of holes connected by a metal strip underneath forms a node. A node is a point in a circuit where two components are connected. Connections between different components are formed by putting their legs in a common node.

The long top and bottom row of holes are usually used for power supply connections. The rest of the circuit is built by placing components and connecting them together with jumper wires. ICs are placed in the middle of the board so that half of the legs are on one side of the middle line and half on the other.

GENERAL DESCRIPTION:

The basic circuit diagram implemented is as shown:



Components Used:

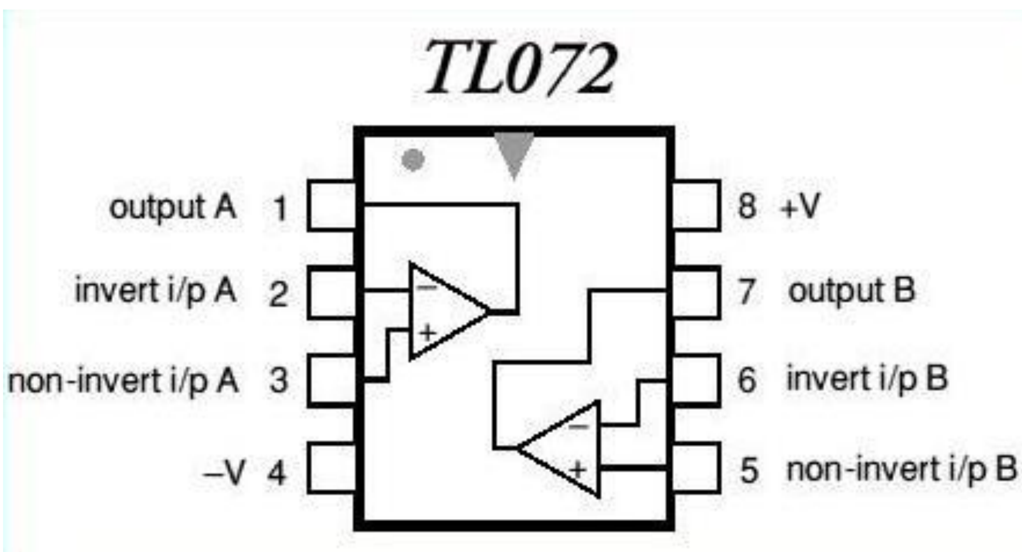
COMPONENTS	QUANTITY	DESCRIPTION
U1A	1	TL072
U2, U3	2	UA741CN
U5	1	LM386CN
C1	1	470µF
C2, C3, C4	3	4.7µF
C5, C6, C7	3	10µF
C10	1	0.2µF
C8	1	0.05µF
C9	1	220µF
C12	1	0.1µF
R1	1	2.2KΩ
R2	1	47KΩ
R3, R9, R10	3	1KΩ
R4	1	10KΩ
R5, R6	2	4.7KΩ
R7, R11	2	33KΩ
R8, R12	2	56KΩ
R13	1	10KΩ POT
R14	1	10Ω
LOUD SPEAKER	1	4Ω, 1W
CLARION DIVIDING NETWORK		
CONDENSOR MICROPHONE		

Pre – Amplifier – TL072:

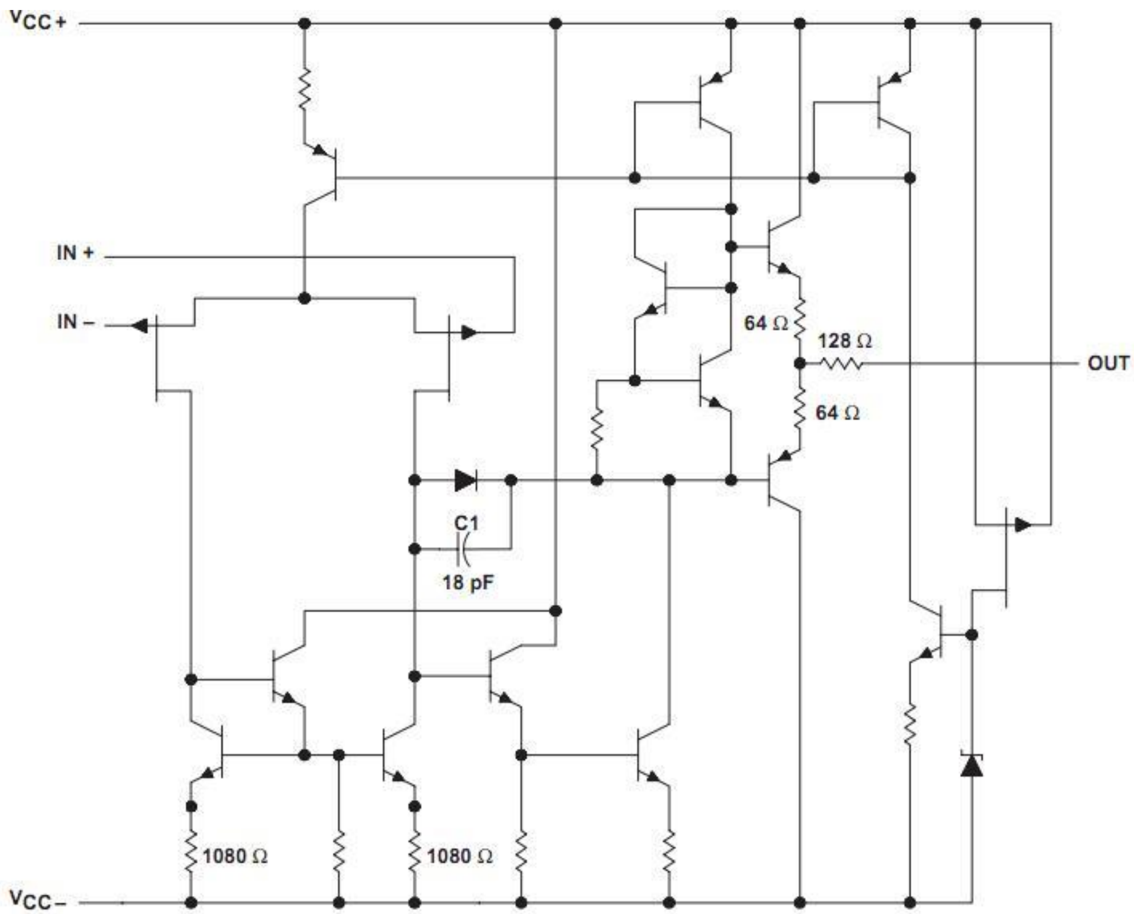
A preamplifier (preamp) is an electronic amplifier that prepares a small electrical signal for further amplification or processing. A preamplifier is often placed close to the sensor to reduce the effects of noise and interference. It is used to boost the signal strength to drive the cable to the main instrument without significantly degrading the signal-to-noise ratio (SNR).

The JFET-input operational amplifiers in the TL07_ series are designed as low-noise versions of the TL08_ series amplifiers with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL07_ series ideally suited for high-fidelity and audio preamplifier applications. Each amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip. The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of –55°C to 125°C.

PIN DIAGRAM:



SCHEMATIC DIAGRAM:



FEATURES:

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion ... 0.003% Typ
- Low Noise

  Vn = 18 nV/√Hz Typ at f = 1 kHz
- High Input Impedance . . . JFET Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes VCC+

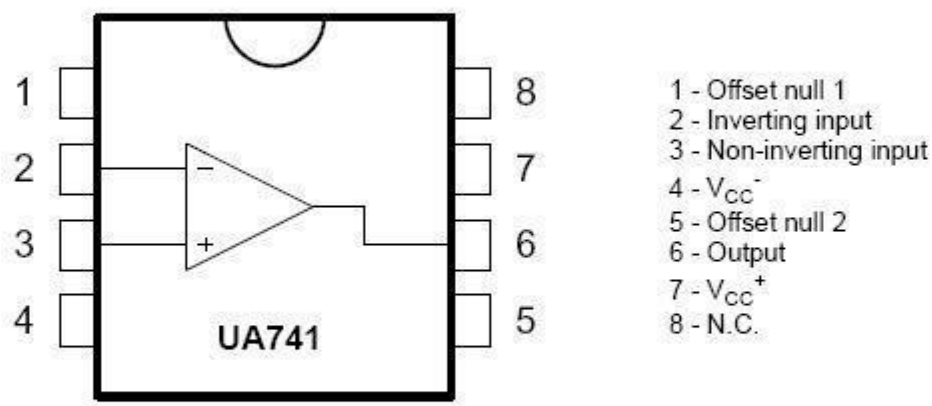
Operational Amplifier – UA741CN:

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications. The amplifiers offer many features:

- Overload protection on the input and output,
- No latch-up when the common mode range is exceeded
- Freedom from oscillations.

The LM741C is identical to the LM741/LM741A except that the LM741C has their performance guaranteed over a 0¢XC to +70¢XC temperature range, instead of .55¢XC to +125¢XC.

PIN CONFIGURATION:



INTERNAL CIRCUITRY OF 741 TYPE OP-AMP:

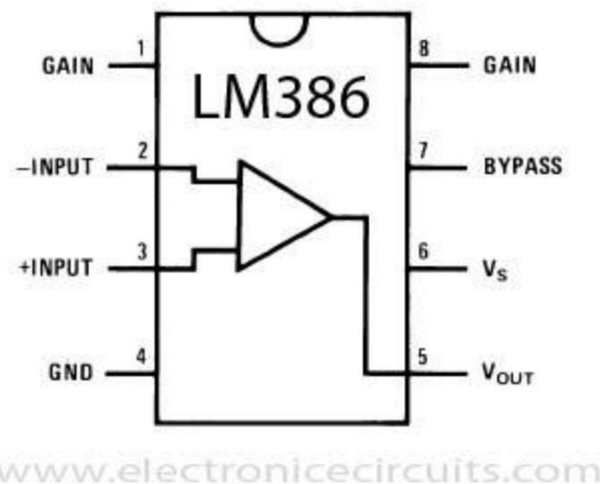
Though designs vary between products and manufacturers, all op-amps have basically the same internal structure, which consists of three stages:

1. **Differential amplifier** – provides low noise amplification, high input impedance, usually a differential output.
2. **Voltage amplifier** – provides high voltage gain, a single-pole frequency roll-off, usually single-ended output.
3. **Output amplifier** – provides high current driving capability, low output impedance, current limiting and short circuit protection circuitry.

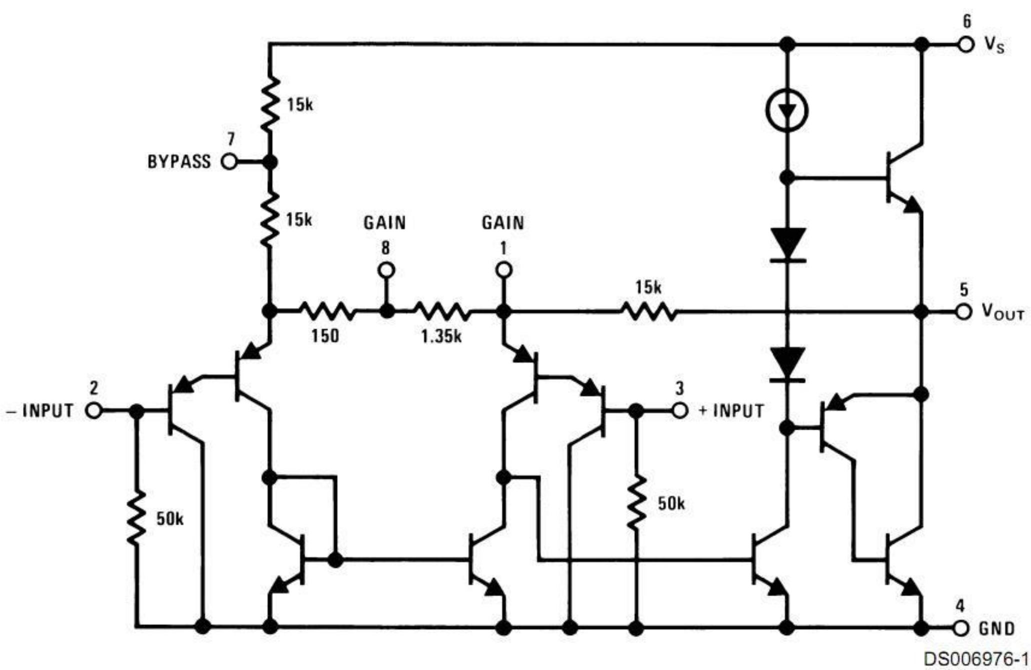
Audio power amplifier – LM386:

The LM386 (aka JRC386) is an integrated circuit consisting of a low voltage audio power amplifier. It is suitable for battery-powered devices such as radios, guitar amplifiers, and hobbyist projects. The IC consists of an 8 pin dual in-line package (DIP-8) and can output 0.5 watts power using a 9-volt power supply.

PIN CONFIGURATION:



INTERNAL CIRCUIT OF LM386:



Microphone:

A microphone is an acoustic-to-electric transducer or sensor that converts sound into an electrical signal. In 1876, Emile Berliner invented the first microphone used as a telephone voice transmitter. Microphones are used in many applications such as telephones, tape recorders, karaoke systems, hearing aids, motion picture production, live and recorded audio engineering, FRS radios, megaphones, in radio and television broadcasting and in computers for recording voice, speech recognition, VoIP, and for non-acoustic purposes such as ultrasonic checking or knock sensors.

Most microphones today use electromagnetic induction (dynamic microphone), capacitance change (condenser microphone, pictured right), piezoelectric generation, or light modulation to produce an electrical voltage signal from mechanical vibration.

LOW-PASS FILTERS:

A low-pass filter is a filter that passes low-frequency signals but attenuates (reduces the amplitude of) signals with frequencies higher than the cutoff frequency. The actual amount of attenuation for each frequency varies from filter to filter. It is sometimes called a high-cut filter, or treble cut filter when used in audio applications. A low-pass filter is the opposite of a high-pass filter, and a band-pass filter is a combination of a low-pass and a high-pass.

The concept of a low-pass filter exists in many different forms, including electronic circuits (like a hiss filter used in audio), digital algorithms for smoothing sets of data, acoustic barriers, blurring of images, and so on. Low-pass filters play the same role in signal processing that moving averages do in some other fields, such as finance; both tools provide a smoother form of a signal which removes the short-term oscillations, leaving only the long-term trend.

Types of low pass filter:

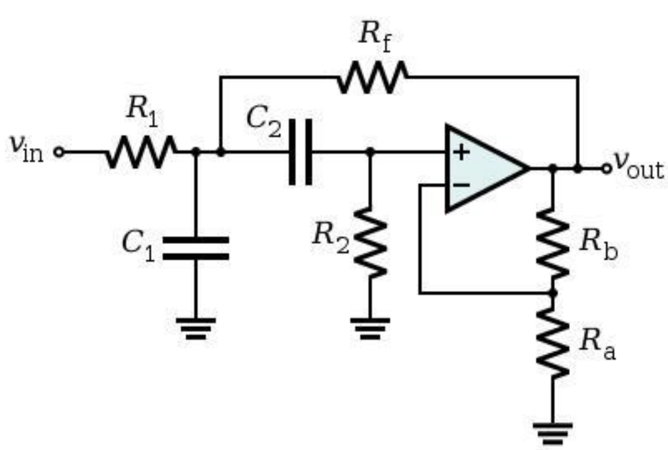
There are many different types of filter circuits, with different responses to changing frequency. The frequency response of a filter is generally represented using a Bode plot, and the filter is characterized by its cutoff frequency and rate of frequency roll off. In all cases, at the cutoff frequency, the filter attenuates the input power by half or 3 dB. So the order of the filter determines the amount of additional attenuation for frequencies higher than the cutoff frequency.

- A first-order filter, for example, will reduce the signal amplitude by half (so power reduces by 6 dB) every time the frequency doubles (goes up one octave); more precisely, the power roll off approaches 20 dB per decade in the limit of high frequency. The magnitude Bode plot for a first-order filter looks like a horizontal line below the cutoff frequency, and a diagonal line above the cutoff frequency. There is also a "knee curve" at the boundary between the two, which smoothly transitions between the two straight line regions. If the transfer function of a first-order low-pass filter has a zero as well as a pole, the Bode plot will flatten out again, at some maximum attenuation of high frequencies; such an effect is caused for example by a little bit of the input leaking around the one-pole filter; this one-pole Vone-zero filter is still a first-order low-pass.

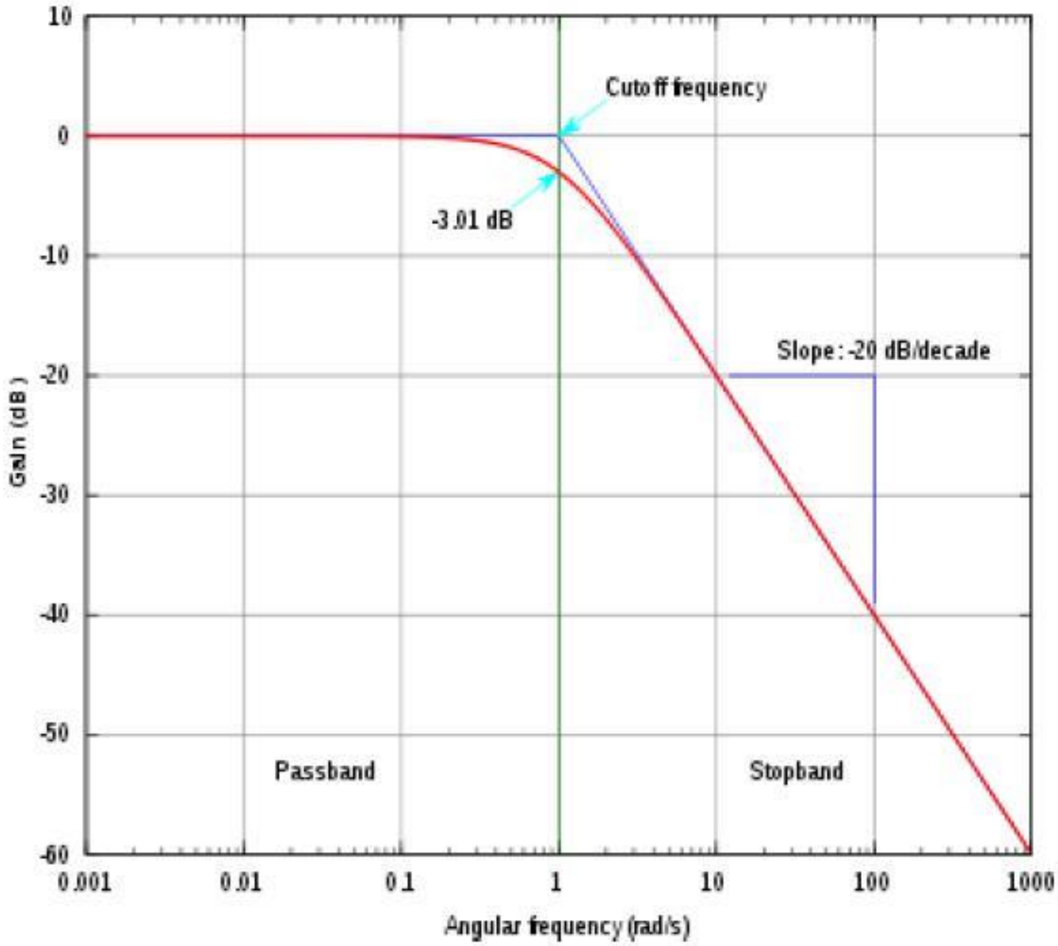
- A second-order filter attenuates higher frequencies more steeply. The Bode plot for this type of filter resembles that of a first-order filter, except that it falls off more quickly. For example, a second-order Butterworth filter will reduce the signal amplitude to one fourth its original level every time the frequency doubles (so power decreases by 12 dB per octave, or 40 dB per decade). Other all-pole second-order filters may roll off at different rates initially depending on their Q factor, but approach the same final rate of 12 dB per octave; as with the first-order filters, zeroes in the transfer function can change the high-frequency asymptote.

- Third- and higher-order filters are defined similarly. In general, the final rate of power roll off for an order-n all-pole filter is 6n dB per octave (i.e., 20n dB per decade).

The figure below shows a Second Order Low Pass Filter:



On any Butterworth filter, if one extends the horizontal line to the right and the diagonal line to the upper-left (the asymptotes of the function), they will intersect at exactly the "cutoff frequency". The frequency response at the cutoff frequency in a first-order filter is 3 dB below the horizontal line. The various types of filters ¡V Butterworth filter, Chebyshev filter, Bessel filter, etc. ¡V all have different-looking "knee curves". Many second-order filters are designed to have "peaking" or resonance, causing their frequency response at the cutoff frequency to be above the horizontal line.

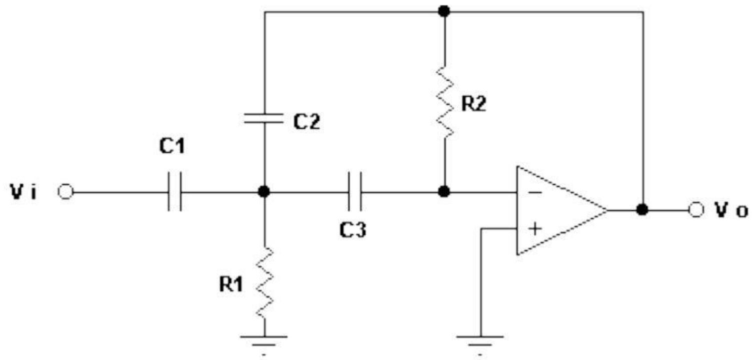


The gain-magnitude frequency response of a first-order (one-pole) low-pass filter. Power gain is shown in decibels. Angular frequency is shown on a logarithmic scale in units of radians per second.

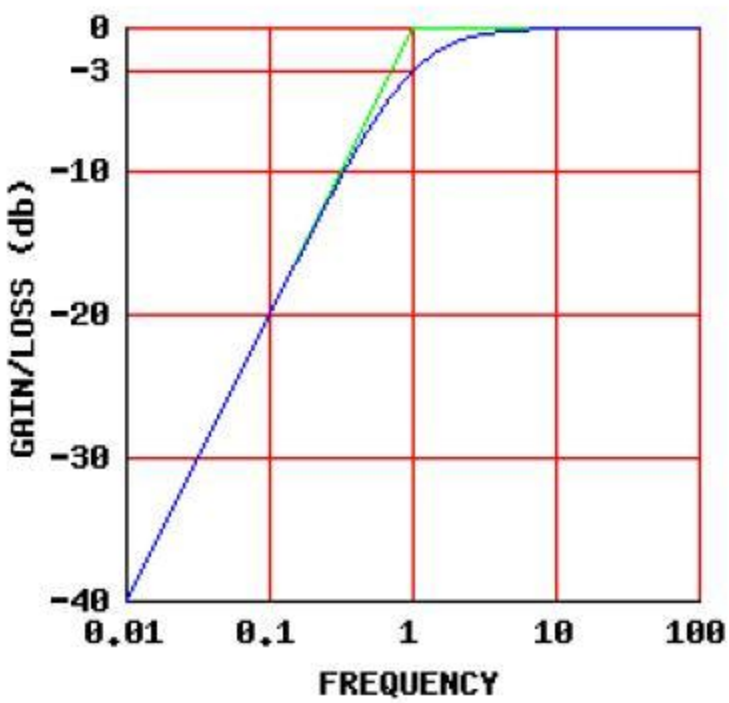
HIGH PASS FILTERS:

A high-pass filter, or HPF, is a filter that passes high frequencies well but attenuates (i.e., reduces the amplitude of) frequencies lower than the filter's cutoff frequency. The actual amount of attenuation for each frequency is a design parameter of the filter.

The figure below shows a Second Order High Pass Filter.



Frequency response:



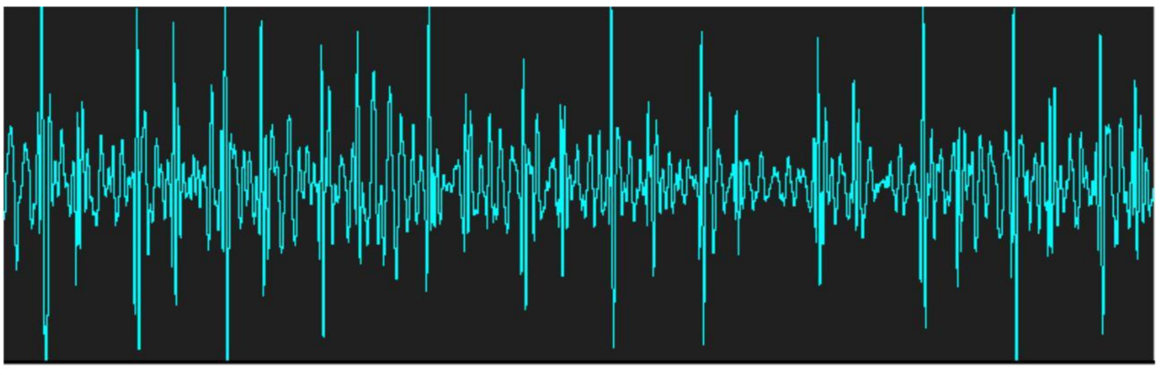
The frequency response of a basic high-pass filter is actually a mirror image of its low-pass counterpart. At the cutoff frequency where R = XL or R = XC, the attenuation is only 3 db, so the signal voltage is still 70.7% of its higher-frequency value.

Below the cutoff frequency, attenuation increases at the rate of 40 db per decade, which is the same roll-off as for the low-pass filter. Above the cutoff frequency, attenuation rapidly decreases to nothing, and all higher frequencies pass with ease.

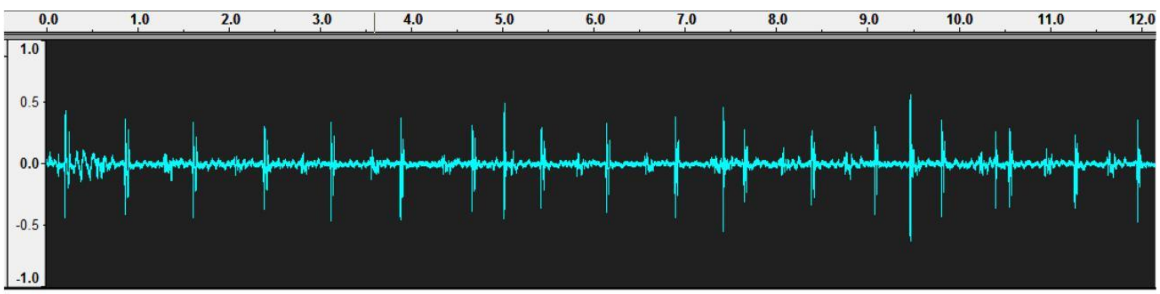
The green line in the graph is the straight line extension of the constant slopes of the actual frequency response. As with the low-pass filter, the intersection point is the cutoff frequency. This straight-line approximation of the real frequency response curve is very easy to draw, and is sufficiently accurate for some kinds of applications. Of course, the actual curve near the cutoff frequency is understood.

OBSERVATIONS:

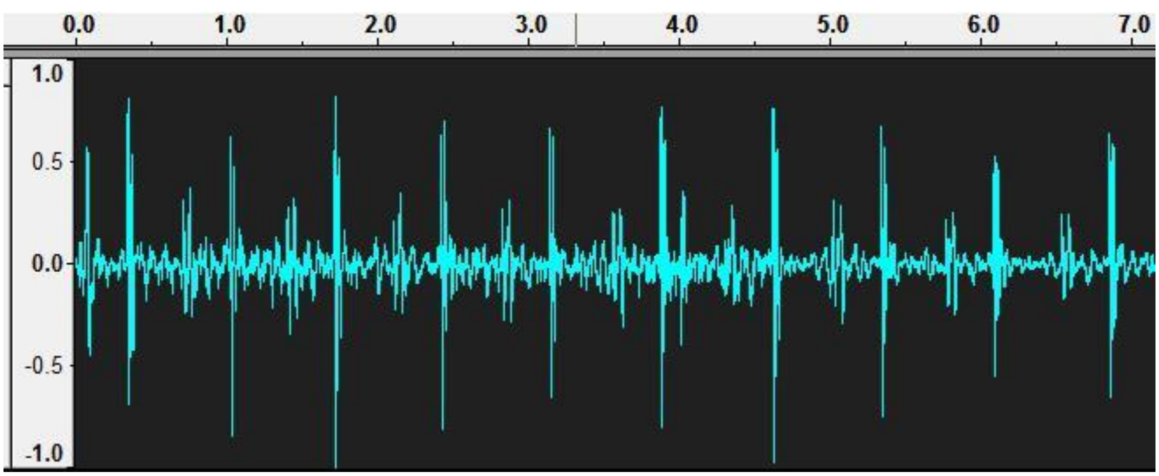
1. Input from heart from the condenser microphone:



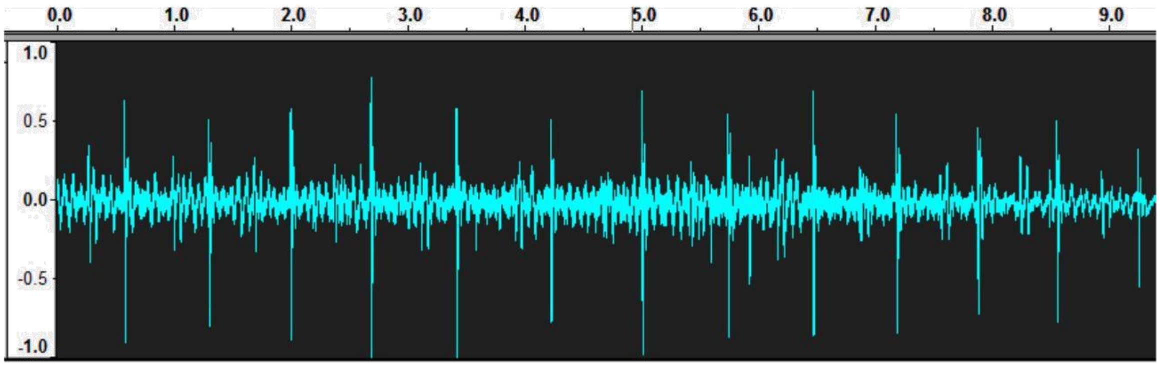
2. Output after the Pre – Amplifier Stage:



3. Output after the Second Order High Pass Filter:



4. Output of Second Order Low Pass Filter:



THINKLABS PHONOCARDIOGRAPHY:

Thinklabs Phonocardiography Software provides easy visualization and editing of heart sounds and lung sounds recorded from your Thinklabs Digital Stethoscope. The software can be downloaded free and works with both PC and Apple Mac computers. With Thinklabs Phonocardiography, you can use your Thinklabs Stethoscope to take Auscultation to a whole new level, whether you are in Medical Education or Clinical Practice. Here are just some of the features and benefits:

Thinklabs System Solutions

Easy to Use

- Record and Playback sounds as if you are using a simple tape recorder.
- Display and visualize sounds very clearly and intuitively.
- Manipulate sounds with ease, using your mouse.
- Save results easily in sound files or group sets of sounds in Project files.

Capture Sounds

- Record from your Thinklabs Stethoscope directly to a Notebook Computer.
- Import recordings from your iPhone, iPod Touch, Sony or other digital recorder. Sound files can be emailed directly from yout iPhone or Touch.
- Import recordings from email attachments or downloaded from the Internet.

Playback and Export Sounds

- Play back sounds on a PC via headphones, or via your Thinklabs Stethoscope.

- Edit and Export sounds to new files for lectures, emails, podcasts, websites, or burn CDs.

Visualize Sounds

- Display heart sound Waveforms.

- Display lung sound Waveforms.

- Display Spectrograms (frequency spectrum) of heart sounds and lung sounds.

- Display Waveform and Spectrograms together to correlate timing and frequency.

- Display FFT's of a segment of sound to observe frequency content.

Manipulate Sounds

- Amplify Sounds after they have been captured.

- Filter recorded sounds to refine recordings or look for specific sound characteristics. Both standard pre-set filters and user-defined filters can be used.

- Rate Change – Slow down recordings so that details such as splits are more audible.

Edit, Annotate and produce Electronic Medical Records

- Cut, Copy or Paste sound segments.

- Label Sound tracks to identify specific events such as S3, S4, murmurs, etc.

- Import groups of sounds for one patient, or a group of patients into Projects that can be saved, so that you can later open a single Project file to access all related Sounds.

- Save images of Waveforms and Spectrograms along with Labels for medical records or research papers.

Auscultation Research for Advanced Users

- Investigate heart sounds and lung sounds for new diagnostic methods.

- Develop software analysis methods. Thinklabs Phonocardiography is built on the award winning Audacity Open Source platform. The software source code is freely available for any researchers or software developers who wish to expand the power of auscultation with new analysis software

FUTURE SCOPE:

- Successful detection of the heartbeat of the fetus inside a mother's womb.
- Digitalization of the heartbeat to find beats per minute, and pulse rate.
- Portability and Miniaturization of the circuit on a PCB.
- Automatic supervision of heartbeat by use of artificial intelligence and robo physicians.
- Direct uploading to latest recording devices like iPod, and also storage in memory cards.

COST OF THE PROJECT:

The Gross Amount of the project is just Rs. 687.00 /-